CMS/LHC Status Report

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Fermilab CMS Center

All Experimenters' Meeting

June 1, 2009

Outline

- LHC Status
- CMS Status
- Physics Preparations at LPC

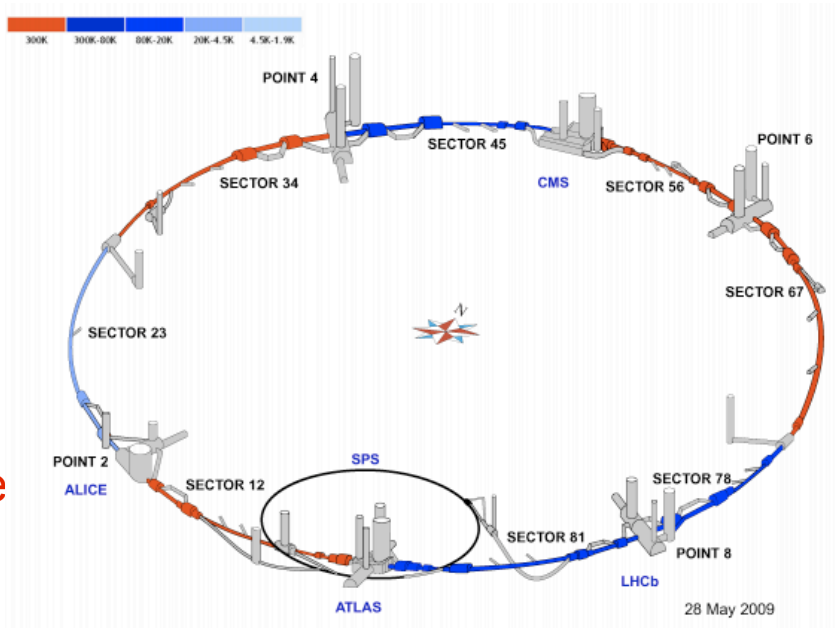
LHC News

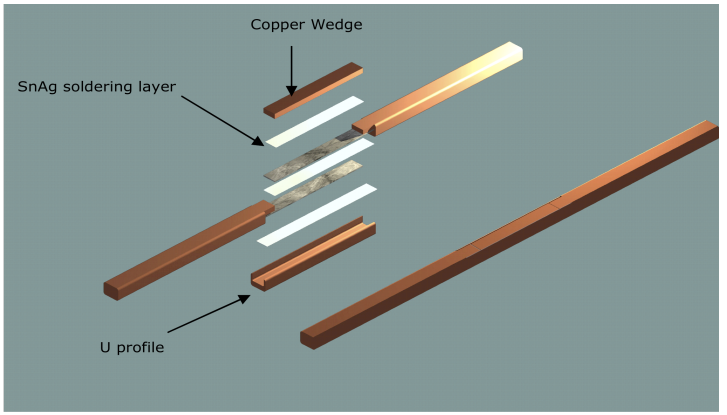
✦ The final magnet for the Sector 34 repairs was lowered (30 April). End of repair work above ground!

✦ Work on new resistance measurement systems (quench protection system), new pressure relief systems, etc., is on schedule

✦ Busbar and magnet splice tests:

- ❖ Four warm sectors: dipole circuits tested → 5 interconnections have resistance "in the tail", will repair
- ❖ Sector 34: don't have this problem – soldering technique is now improved
- ❖ Sector 23: splice measurements done. Cooled down to 4-6K.
- ❖ Sector 45: the copper stabilizer gap measurements in the interconnection splices have been carried out two week ago





LHC Schedule-Towards the First LHC Physics Run

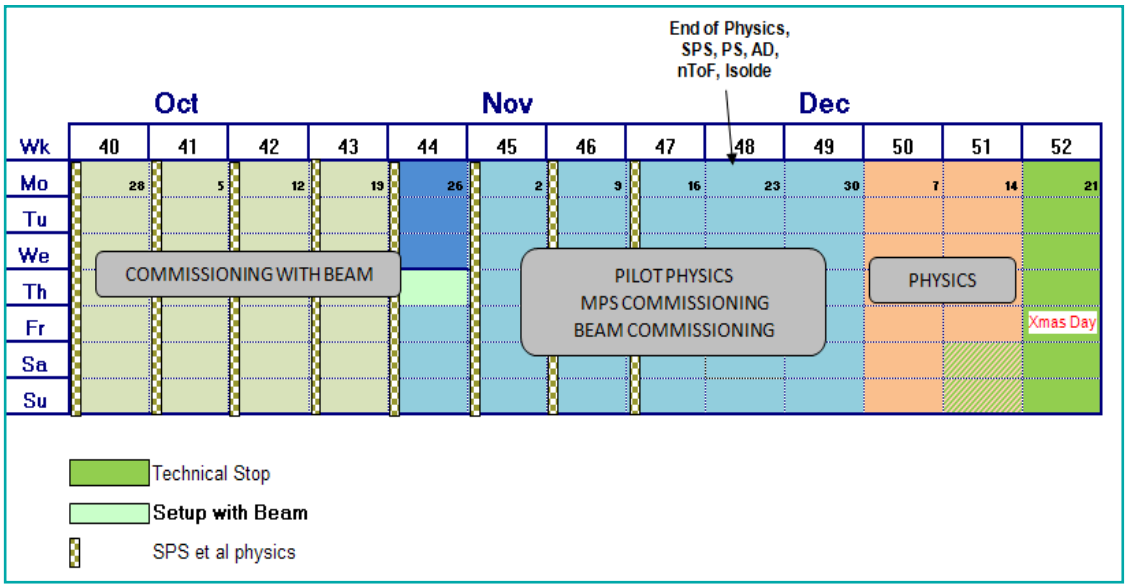
… an integrated luminosity of more than 200 pb^{-1} operating at 5 TeV per beam …

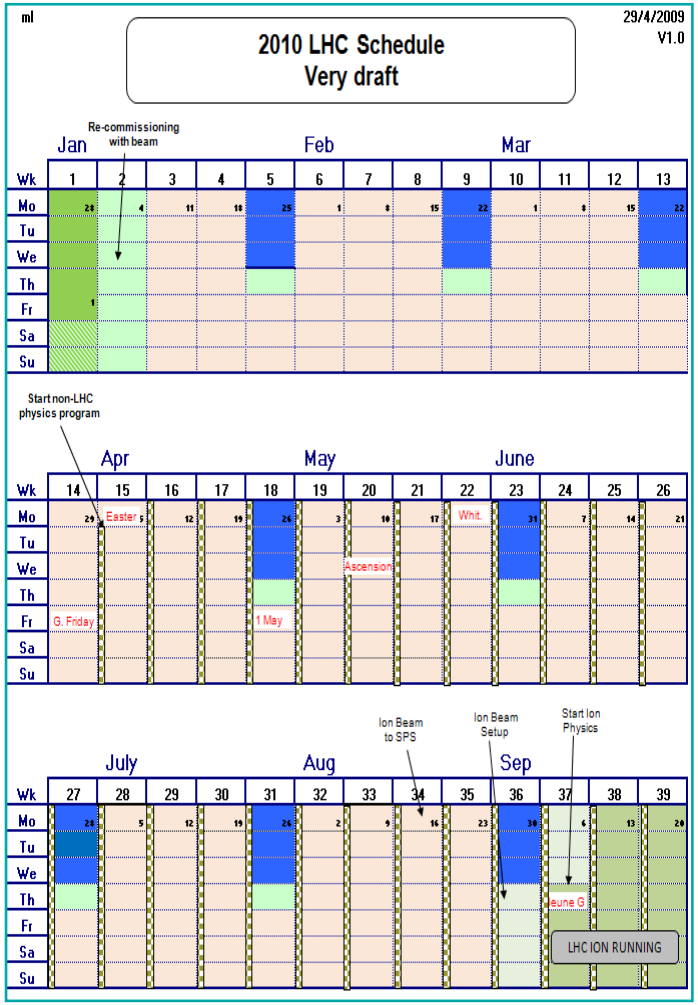
✦ Inputs from LHC experiments: start to be competitive with Tevatron for Higgs mass around 160 GeV mass.

✦ Inputs from LHC: Phase 1 collimation system, expected maximum intensity (limited by loss rate and quench limit)

✦ Run through winter with non-stop scenario or two-week stop scenario till next fall.

✦ Luminosity to go above 10^{32} cm^{-2}s^{-1} (50 ns bunch crossing)





Caveat

"*Since the incident of 19 September, we have learned a great deal about the failure mode of magnet interconnects. We have developed highly sensitive methods to detect resistances of splices at the nano-ohm level. If you have been following the LHC updates in the Bulletin, you'll know that a small number of splices with abnormally high resistance has been found, and these are being investigated, understood and dealt with. The most recent discovery we have made concerns the copper bus bar in which the superconductor is embedded. Although copper can't carry the same level of current as the superconducting cable for sustained periods, it plays the essential role of providing a low resistance path to the current when a magnet or a bus bar quenches: copper gives time to the protection system to discharge the stored energy. Careful tests have revealed that in some cases, the process of soldering the superconductor in the interconnecting high-current splice can melt the solder joining the superconducting cable to the copper of the bus bar, and thereby impede its ability to do its job in case of a quench. As a result of this we're improving the soldering process, and checking the whole of the LHC for similar faults: a test has been done for sectors at room temperature and studies are now going on to allow the same procedure at cryogenic, but non superconducting temperatures. So far, three sectors have been tested at room temperature, and five potentially faulty interconnections found. This low number is a promising signal for the rest of the machine, but since caution is our guiding principle, if faults are found they will be repaired and we'll recover the time by prolonging the first LHC physics run.*"

Rolf Heuer, CERN DG, 4 May 2009

Activities in CMS Cavern

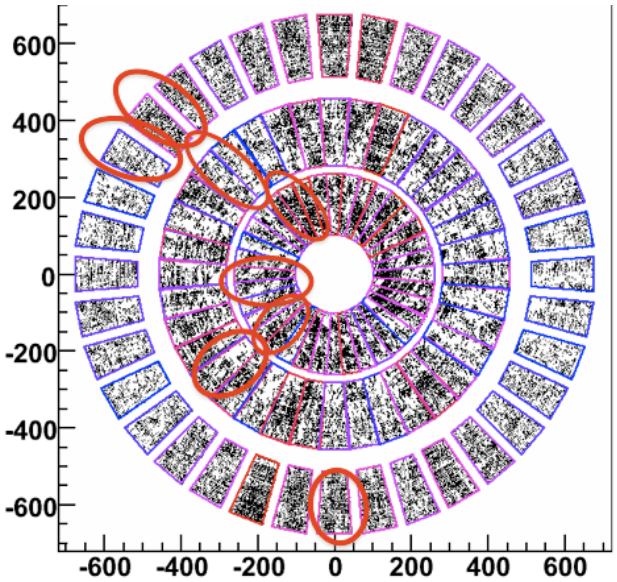
✦ Closing with pauses at intermediate steps to allow work on Tracker and Endcap Muon system

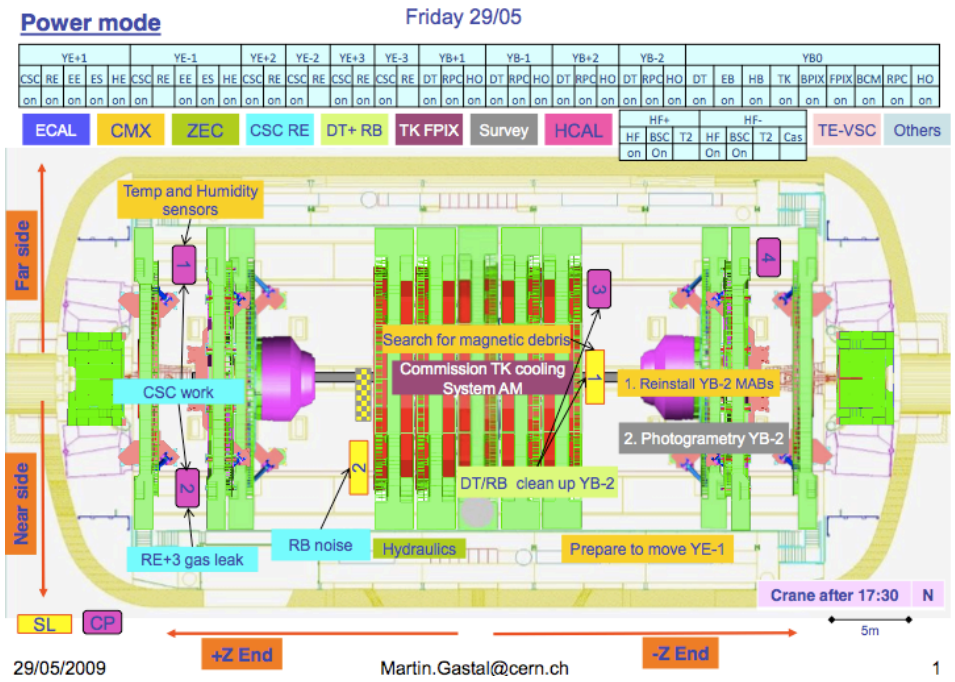
✦ Tracker cooling plants.

✤ Plant1: tank pressure test, leakage test, test run in by-pass, ...

✤ Plant2: pressure test started in May 19, ...

✤ Full operation in first week of June





✦ Lots of hard work to get data from endcap Muon system missed in last year global runs.

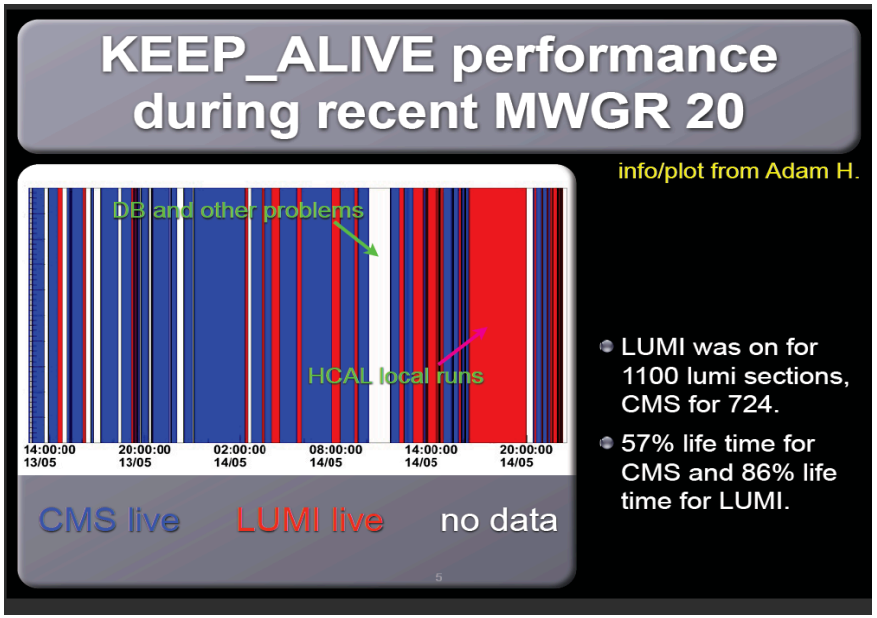
✦ Yoke Endcap +/-1 will be closed in first week of June.

CMS Commissioning

- ✦ Continue with Mid. Week Global Run (MWGR).
- ✦ System included:
  L1 trigger, DAQ, ECAL, HCAL, Drift Tube, RPC, Cathode Strip Chamber, Pixels.
- ✦ System excluded:
  pre-shower, strip tracker.
- ✦ Few highlights:
- ✦ High-level trigger readout rates were tested (100 kHz input rate, ~5% dead time)
- ✦ Bug in the timing of the L1 Global Calorimeter Trigger were resolved.
- ✦ Luminosity Monitoring achieved continuous running. (based on CMS Forward Hadron Calorimeter)

May

Su	Mo	Tu	We	Th	Fr	Sa
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						



CMS Schedule

Mar
Apr
May
Jun
Jul
Aug
Sep
Oct

Endcap preshower installation: Done!

Tracker cooling plant revised

Tracker cooling plant ready & tracker checkout

Close CMS

Magnet Tests

CRAFT contingency & pre-beam maintenance

Longer continuous running WITHOUT magnetic field

WITH full magnetic field (CRAFT)

CMS will be ready again for beam well before the LHC restart-up!

LPC Physics Activities - Resources

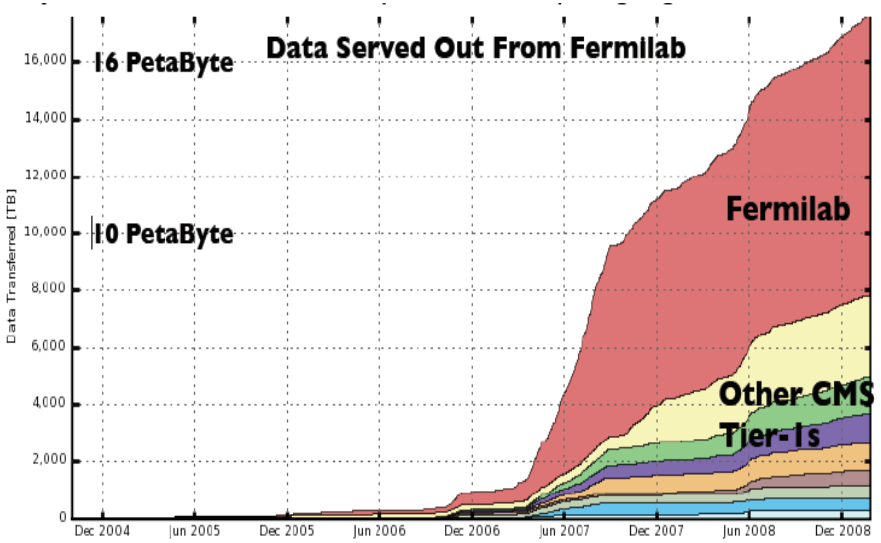
✦ Remote Operation Center actively participated in the CMS global runs: DQM, subsystem shifts, etc.

✦ Fermilab Tier-1 facility:
data processing and serving (to Tier-2s, and LPC CMS Analysis Farm)

✦ Analysis facility LPC-CAF.

✤ Clear division between LPC-CAF and the Tier-1 resources

✤ Full access to Tier-1 mass storage system.



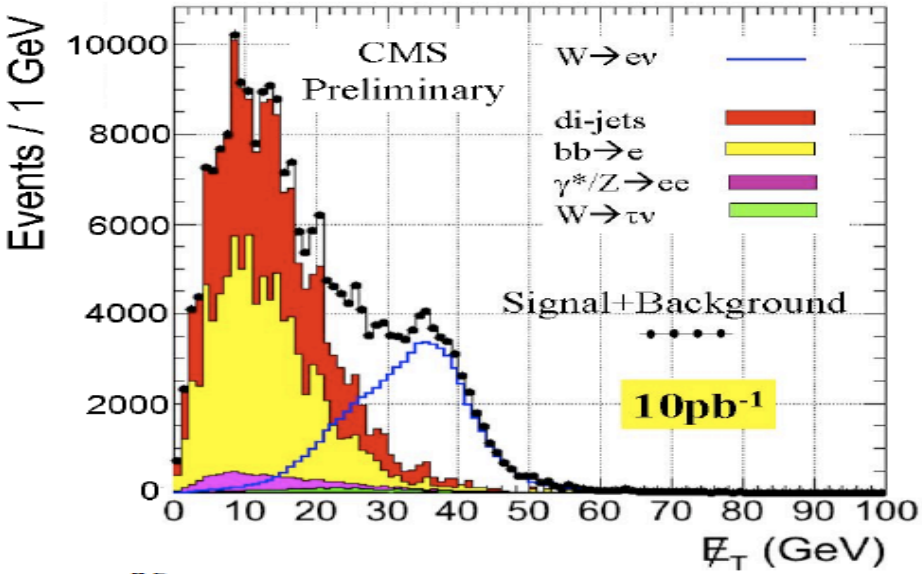
FNAL Tier-1 and LPC Winter 2009	Tier-1+LPC	1148 nodes	Processing Nodes
	Tier-1+LPC	12.7MSI2k	Processing Capacity
	Nominal Split	5100 T1, 2400 LPC	Batch slots
	Disk T1	2.0PB	dCache (1600MB/s IO)
	Disk LPC	0.5PB	Dedicated to Local Analysis
	Network	15Gb/s	CERN to FNAL

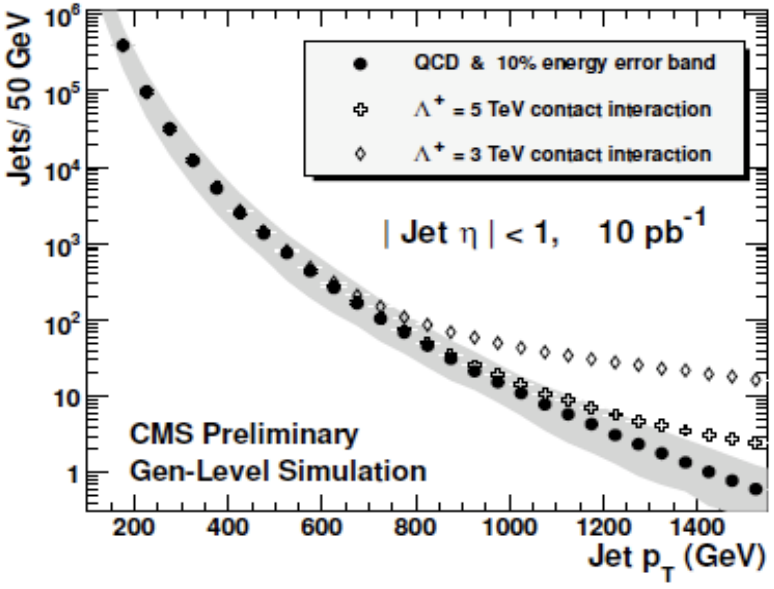
Selected Physics Topics

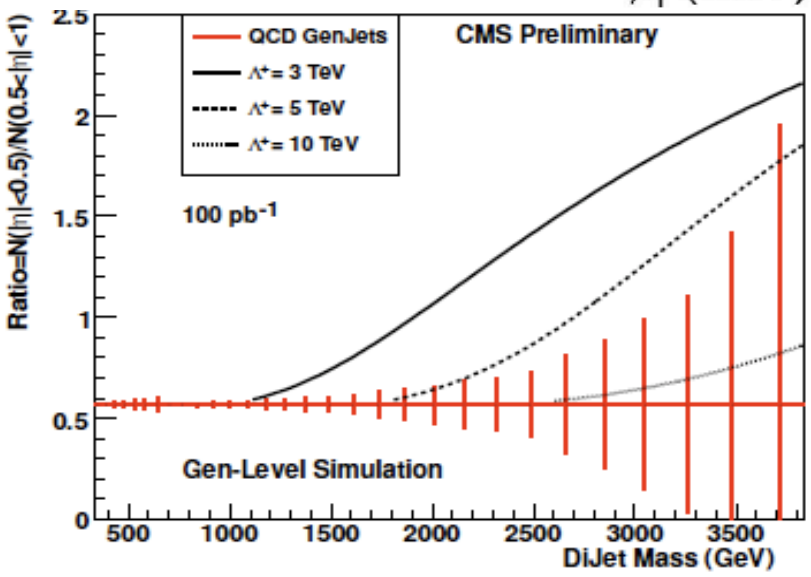
✦ Five “di-objects” signature groups at LPC:

- ✤ jet+jet, photon+jet, dilepton, jet+MET, lepton+ jet + MET

✦ Very rich physics programs: J/psi, Upsilon, W/Z physics, top, Higgs, exotic particle searches (W’, Z’, ...), etc.







Summary

- LHC repairs and improvements are on schedule.
  - First physics run is drafted with the goal to accumulate over 200 pb^{-1} of luminosity at ~10 TeV.
  - The time (if needed to fix more faults in interconnects) will be recovered by prolonging the first LHC physics run.
- The CMS is getting ready again for beam
  - Work on strip tracker cooling plants and Endcap Muon system is progressing well.
  - The CMS is continuing with global runs: hardware/software debug, integrate more sub-systems, shaking down operation procedures.
- Physics efforts at LPC are ramping up. Looking forward to the first physics run at LHC!

Back-up Slides

CMS Commissioning

- ✦ Continue with Mid. Week Global Run (MWGR).
- ✦ System included: L1 trigger, DAQ, ECAL, HCAL, Drift Tube, RPC, Cathode Strip Chamber, Pixels.
- ✦ System excluded: pre-shower, strip tracker.
- ✦ High-level trigger readout rates were tested (100 kHz input rate, ~5% dead time)
- ✦ Luminosity monitoring, timing issue in L1 Global Calorimeter Trigger, etc.

May

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					1	2
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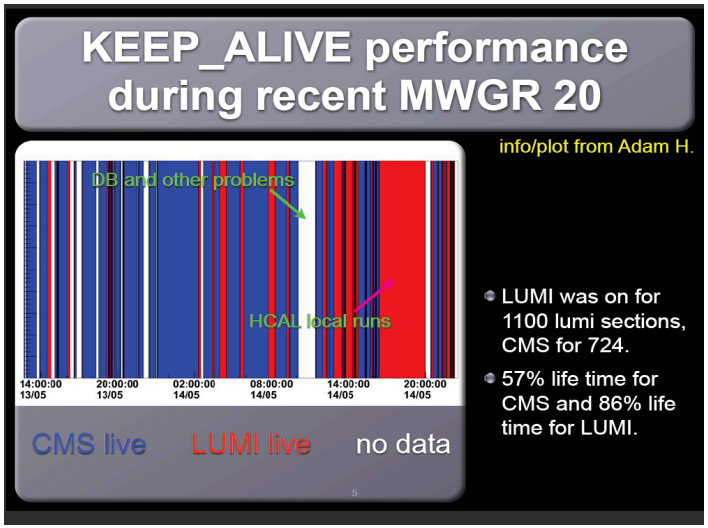
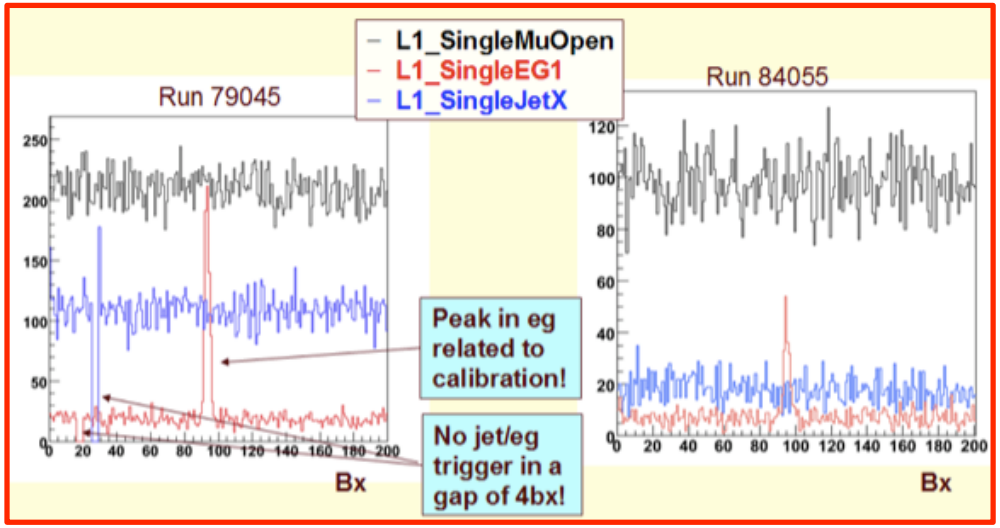
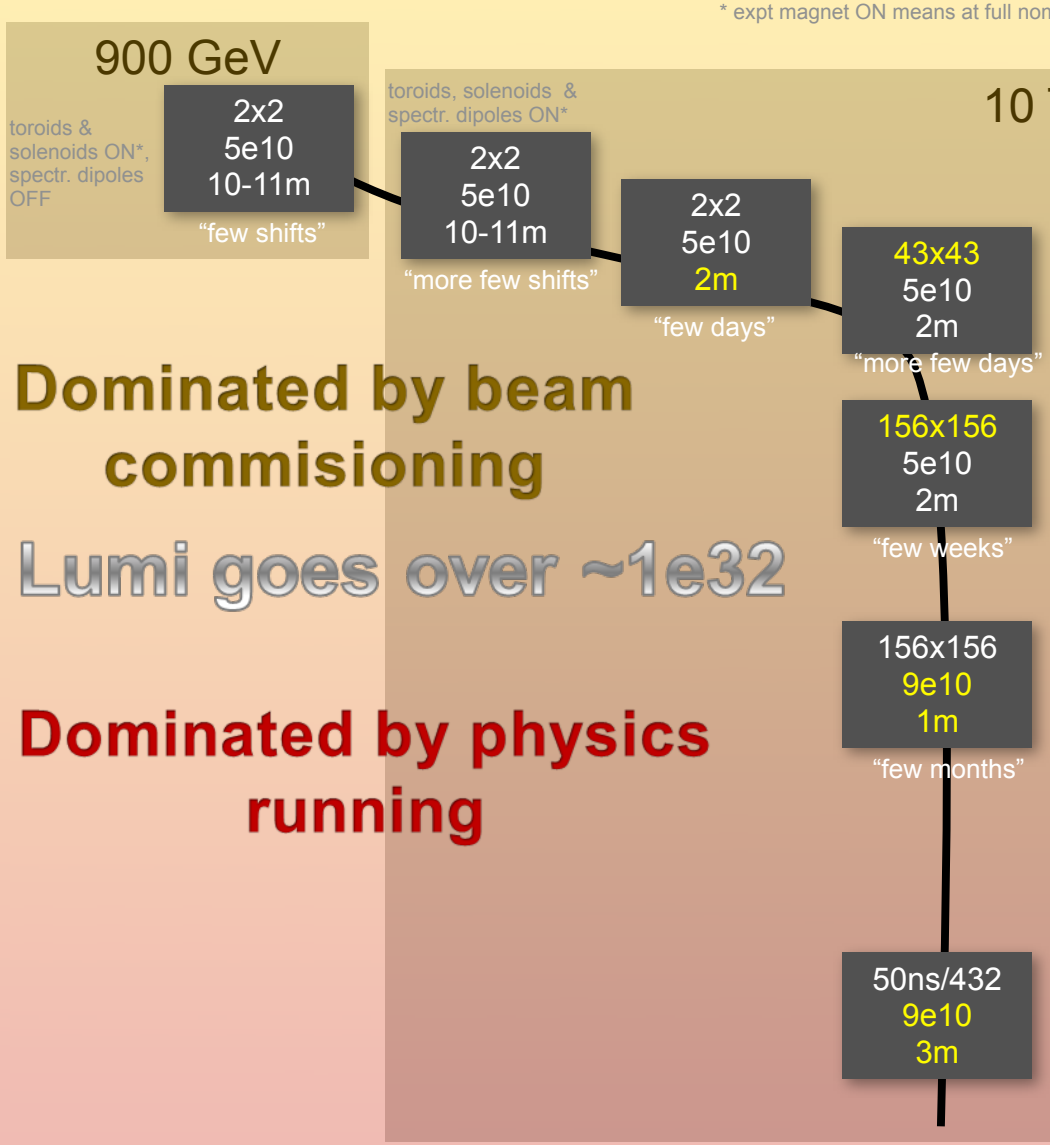




Physics Run Modes

* expt magnet ON means at full nominal field (as for 14 TeV)



develop 50 ns, truncated

introduces crossing angle

short physics runs at 50 ns and go back to best luminosity (156x156) for mass lumi production

until 50ns breaks even (then stay at 50 ns)

try also 25 ns at the end

Overview Table

Steps for luminosity increase during the 2009-2010 LHC *pp* run

	900 GeV	first high-energy coll.		Pilot physics run: no external crossing angle			Pilot physics run: with external crossing angle				
step	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	...	units
fill scheme	2x2	=	=	43x43	156x156	156x156	50ns@144	50ns@288	50ns@432	...	
E	**0.45**	**5**	=	=	=	=	=	=	=	...	TeV
k_b	2	=	=	**43**	**156**	=	**144+12**	**288+12**	**432+12**	...	bunches
N	5	=	=	=	=	**9**	=	=	=	...	10^{10} p/bunch
N_{Alice}	5	=	=	=	=	=	1	=	=	...	10^{10} p/bunch
β^*(IP1,5)	11	=	**2**	=	=	**1**	3	=	=	...	m
β^*(IP2)	10	=	=	=	=	=	3	=	=	...	m
β^*(IP8)	10	=	**2**	=	=	**3**	4	=	=	...	m
I/I_{nom}	0.031	=	=	0.67	2.42	4.3	4.05	8.1	12.1	...	%
E_{stored}	0.0072	0.08	=	1.72	6.24	11.1	10.5	20.8	31.2	...	MJ
α_{net}(IP1,5)	0	0	=	=	=	=	300	=	=	...	μrad
α_{net}(IP2)	0	200	=	=	=	=	300	=	=	...	μrad
α_{net}(IP8)	0	380	=	=	=	=	620	=	=	...	μrad
n_{bb}(IP1,5)	1	=	=	43	156	156	144	288	432	...	colliding pairs
n_{bb}(IP2)	1	=	=	4	=	=	12	=	=	...	colliding pairs
n_{bb}(IP8)	1	=	=	19	72	=	138	276	414	...	colliding pairs
L(IP1,5)	0.0026	0.029	0.16	6.9	24.9	161.5	48.3	96.5	145	...	10^{30} cm^{-2}s^{-1}
L(IP2)	0.0029	0.032	=	0.13	=	=	0.05	=	=	...	10^{30} cm^{-2}s^{-1}
L(IP8)	0.0029	0.032	0.15	2.8	10.8	23.7	32.7	65.4	98.1	...	10^{30} cm^{-2}s^{-1}
μ(IP1,5)	0.012	0.19	1.07	=	=	6.9	2.24	=	=	...	
μ(IP2)	0.013	0.21	=	=	=	=	0.028	=	=	...	
μ(IP8)	0.013	0.21	1.0	=	=	2.3	1.58	=	=	...	
Time for physics	~shifts	~days		~weeks			~months				

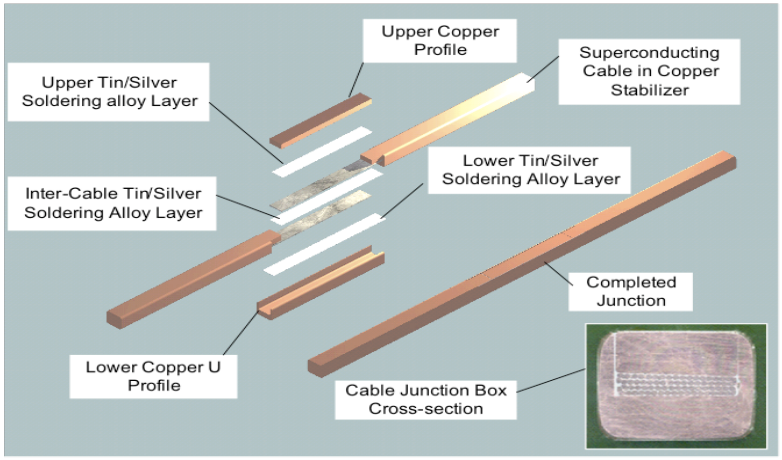
Definitions: μ = average number of inelastic interactions per crossing
n_{bb} = number of colliding pairs at given IP
α_{net} = net crossing angle

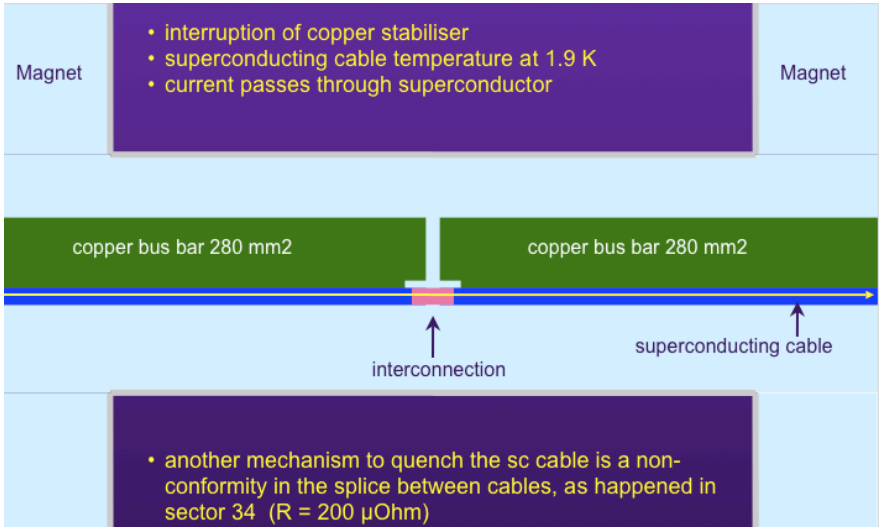
Assumptions: Longitudinal emittance $\epsilon = 0.5$ nm $\cdot$ 7 TeV$/E$
Inelastic cross section: $\sigma_{\mathrm{inel}} = 52$ and 75 mb for $\sqrt{s} = 0.9$ and 10 TeV

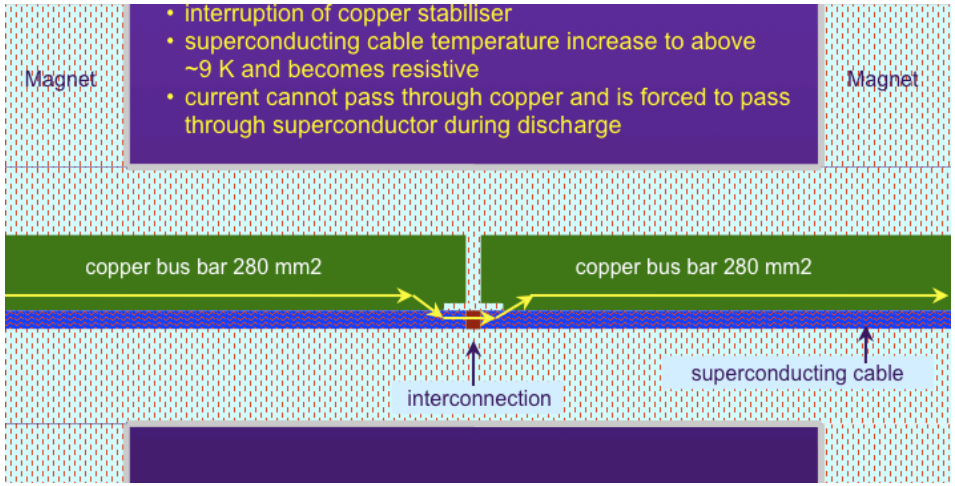
Estimates: Beam commissioning time* for reaching step 6 $\approx$ six weeks
Beam commissioning time* to go from step 6 to step 7 $\approx$ two weeks
Total expected physics running time: of the order of $5 \cdot 10^6$ s

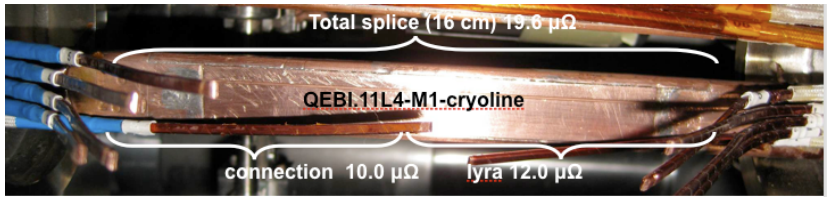
* with machine available

Busbar


Upper Copper Profile
Superconducting Cable in Copper Stabilizer
Upper Tin/Silver Soldering alloy Layer
Lower Tin/Silver Soldering Alloy Layer
Inter-Cable Tin/Silver Soldering Alloy Layer
Completed Junction
Lower Copper U Profile
Cable Junction Box Cross-section

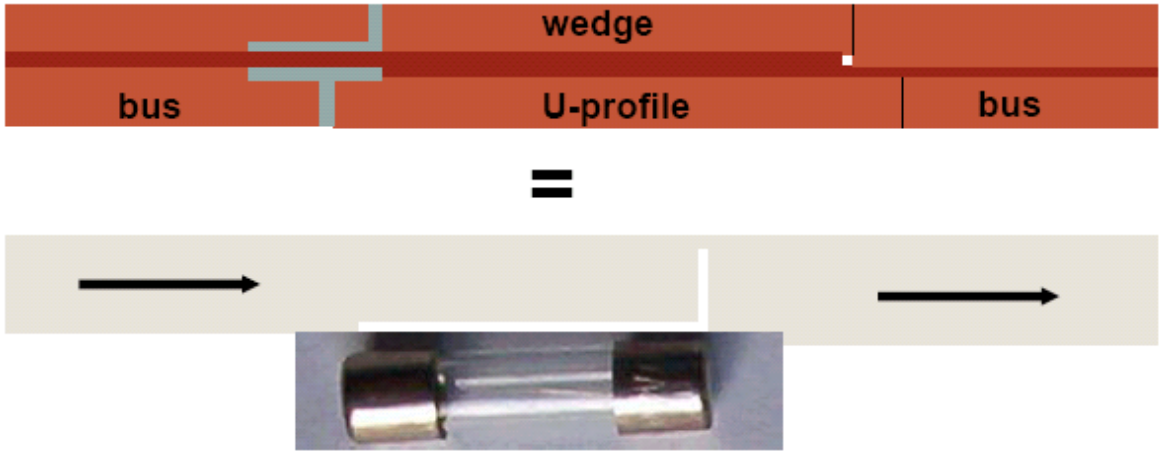

Magnet
• interruption of copper stabiliser
• superconducting cable temperature at 1.9 K
• current passes through superconductor
Magnet
copper bus bar 280 mm2
copper bus bar 280 mm2
interconnection
superconducting cable
• another mechanism to quench the sc cable is a non-conformity in the splice between cables, as happened in sector 34 (R = 200 µOhm)


Magnet
• interruption of copper stabiliser
• superconducting cable temperature increase to above ~9 K and becomes resistive
• current cannot pass through copper and is forced to pass through superconductor during discharge
Magnet
copper bus bar 280 mm2
copper bus bar 280 mm2
interconnection
superconducting cable


Total splice (16 cm) 19.6 µΩ
QEBI.11L4-M1-cryoline
connection 10.0 µΩ
lyra 12.0 µΩ

Condition for a 'silent killer':
Interruption of the longitudinal stabilizer coinciding with lack of thermal bounding of the cable over a few cm.

Condition for a bus burn-through:
Silent killer, high current, and quenching bus (due to beam losses, mechanical movement, warm helium).



A. Verweij, TE-MPE. 28 April 2009, TE-TM meeting

- A handful high resistance cases have been found (long. interruption)
- Assumed to be silent killers with high probability (most joints have a lack of thermal bonding over few cm)